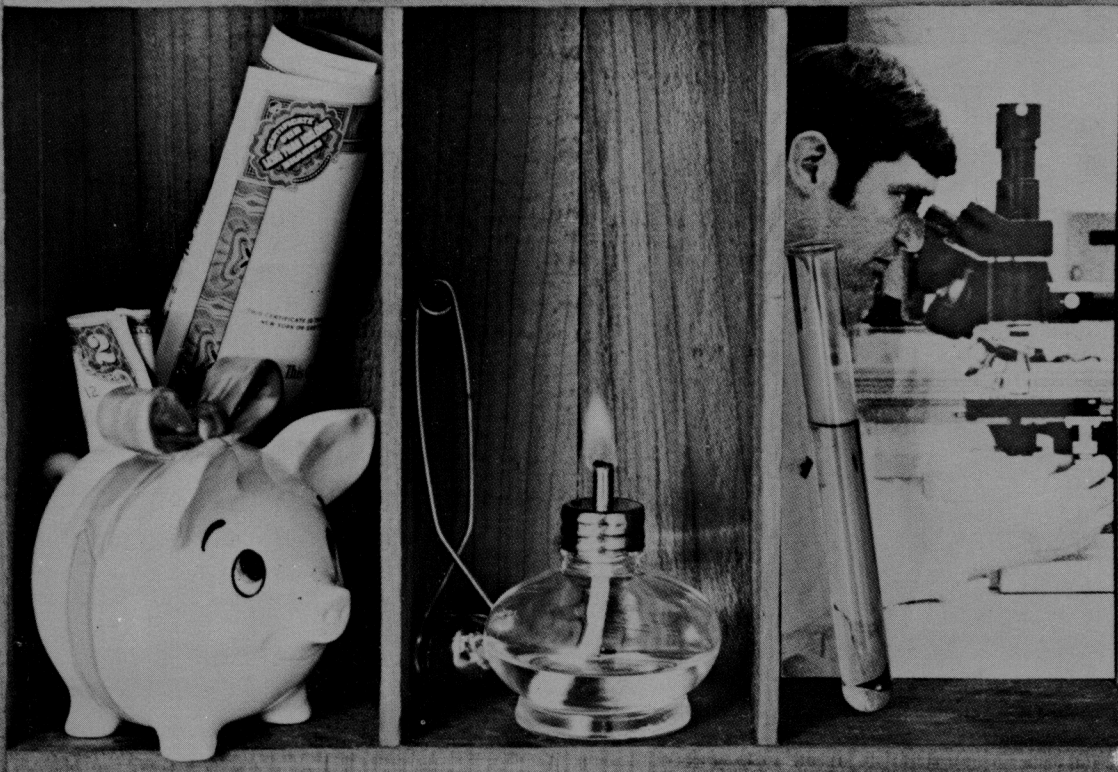


Hewlett-Packard  
**HP-19C/HP-29C**  
**SOLUTIONS**

**STUDENT ENGINEERING**



## INTRODUCTION

This HP-19C/HP-29C Solutions book was written to help you get the most from your calculator. The programs were chosen to provide useful calculations for many of the common problems encountered.

They will provide you with immediate capabilities in your everyday calculations and you will find them useful as guides to programming techniques for writing your own customized software. The comments on each program listing describe the approach used to reach the solution and help you follow the programmer's logic as you become an expert on your HP calculator.

You will find general information on how to key in and run programs under "A Word about Program Usage" in the Applications book you received with your calculator.

We hope that this Solutions book will be a valuable tool in your work and would appreciate your comments about it.

The program material contained herein is supplied without representation or warranty of any kind. Hewlett-Packard Company therefore assumes no responsibility and shall have no liability, consequential or otherwise, of any kind arising from the use of this program material or any part thereof.

## TABLE OF CONTENTS

RESISTIVE/REACTIVE CIRCUIT CALCULATIONS . . . . .	1
Performs resonance calculations.	
IMPEDANCE OF LADDER NETWORK . . . . .	5
Computes input impedance of arbitrary ladder network.	
STANDARD RESISTANCE VALUES. . . . .	8
Computes nearest standard value.	
EXPONENTIAL GROWTH OR DECAY . . . . .	11
Performs calculations for generalized growth and decay phenomena.	
EQUATIONS OF MOTION . . . . .	14
Calculates an interchangeable solution for object moving under constant acceleration.	
KINETIC ENERGY. . . . .	17
Calculates an interchangeable solution for weight (mass), velocity, and kinetic energy.	
RPM/TORQUE/POWER. . . . .	20
This program provides interchangeable solutions for RPM, torque, and power.	
BLACKBODY THERMAL RADIATION . . . . .	23
This program calculates the wavelength of maximum emissive power for a given temperature (or vice versa), and the emissive power (total, from $\lambda_1$ to $\lambda_2$ , or at $\lambda$ ).	
CONSERVATION OF ENERGY. . . . .	28
This program converts kinetic energy, potential energy, and pressure-volume work to energy, sums all the energy contributions, and converts the total to an equivalent velocity, height, pressure, or energy per unit mass.	
MOHR CIRCLE FOR STRESS . . . . .	32
This program calculates the principal stresses and their orientation given the state of stress on an element, and the maximum shear stress and its orientation.	
POLYNOMIAL EVALUATION (REAL OR COMPLEX) . . . . .	36
Evaluates polynomials with real or complex coefficients.	
SINE, COSINE AND EXPONENTIAL INTEGRALS. . . . .	39
Evaluates the sine, cosine and exponential integral by means of a series approximation.	

## RESISTIVE/REACTIVE CIRCUIT CALCULATIONS

This program performs resonance calculations for R-L-C circuits, calculates the reactance of inductive and capacitive branches, the equivalent value of series capacitors or parallel resistors and inductors, and performs power calculations for resistive branches using straightforward manipulations of the following equations:

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$X_C = \frac{1}{2\pi fC}$$

$$X_L = 2\pi fL$$

$$P = I^2R = E^2/R$$

$$\frac{A_1 A_2}{A_1 + A_2} = A_3$$

where

$f_r$  = resonant frequency in hertz

$L$  = inductance in henrys

$C$  = capacitance in farads

$X_C$  = capacitive reactance in  $\Omega$

$X_L$  = inductive reactance in  $\Omega$

$P$  = power in watts

$I$  = current in amps

$R$  = resistance in  $\Omega$

$E$  = voltage in volts

$A_1, A_2$  = the values of two parallel resistors in ohms, two parallel inductors in henrys, or two series capacitors in farads

$A_3$  = the resultant, equivalent resistance in ohms, inductance in henrys, or capacitance in farads

NOTE: Given a resistance or capacitance,  $A_1$ , the value of the circuit element required to produce a desired resultant resistance or capacitance may be calculated by entering  $A_1$  as a negative value.

### EXAMPLES:

1.  $C = .01\mu F$ ,  $L = 160\mu H$ .  
Calculate  $f_r$
2.  $L = 2.5H$ ,  $f_r = 60Hz$   
Calculate  $C$  and  $X_L$  at  $f_r$
3.  $E = 345V$ ,  $R = 1.25M\Omega$   
Calculate  $P$  and  $I$
4.  $R_1 = 120\Omega$ ,  $R_2 = 240\Omega$ 
  - a. Find the equivalent resistance of these two resistors in parallel,  $R_3$ .
  - b. Parallel  $R_3$  with  $50\Omega$ .
  - c. Find the resistance required for a resultant resistance of  $25\Omega$ .

SOLUTION:

```

      ENG4
160.-06 ENT↑
  0.01-06 GSB1
125.82+03 *** fr

  60.0000 ENT↑
  2.5000 GSB2
2.8145-06 *** C

  60.0000 ENT↑
  2.5000 GSB4
942.48+00 *** XL

 345.0000 ENT↑
  1.25+06 GSB5
95.220-03 *** P

  1.25+06 GSB7
276.00-06 *** I

 120.0000 ENT↑
 240.0000 GSB9
 80.000+00 *** R3

  50.0000 GSB9
30.769+00 *** 4b
      CHS
  25.0000 GSB9
133.33+00 *** 4c

```



# Program Listings

01 #LBL1					
02 x					
03 JX					
04 GT00					
05 #LBL2					
06 X $\neq$ Y					
07 GSB0					
08 X $\neq$					
09 X $\neq$ Y					
10 =					
11 R/S	L or C				
12 #LBL3					
13 x					
14 GT00					
15 #LBL4					
16 x					
17 GSB0					
18 1/X					
19 R/S	X <sub>L</sub>				
20 #LBL5					
21 1/X					
22 #LBL6					
23 X $\neq$ Y					
24 X $\neq$					
25 x	P				
26 R/S					
27 #LBL7					
28 1/X					
29 #LBL8					
30 x					
31 JX	I or E				
32 R/S					
33 #LBL0					
34 2					
35 x					
36 P <sub>i</sub>					
37 x					
38 1/X	f <sub>r</sub> or X <sub>C</sub>				
39 RTN					
40 #LBL9					
41 x					
42 ENT↑					
43 ENT↑					
44 LSTX					
45 =					
46 LSTX					
47 +	A <sub>3</sub> or A <sub>2</sub>				
48 =					
49 R/S					
REGISTERS					
0	1	2	3	4	5
6	7	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## IMPEDANCE OF A LADDER NETWORK

This program computes the input impedance of an arbitrary ladder network. Elements are added one at a time starting from the right. The first element must be in parallel.

Suppose we have a network whose input admittance is  $Y_{in}$ . Adding a shunt R, L, or C, the input admittance becomes

$$Y_{new} = \begin{cases} Y_{in} + \left(\frac{1}{R} + j0\right) \\ Y_{in} + \left(0 - j \frac{1}{\omega L_p}\right) \\ Y_{in} + (0 + j \omega C_p) \end{cases}$$

Adding a series R, L, or C, we have

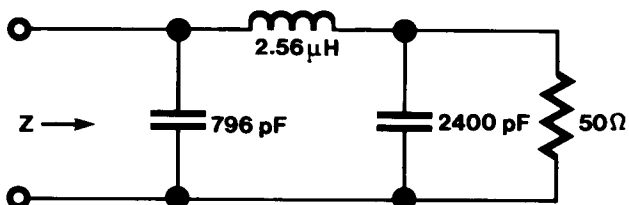
$$Y_{new} = \begin{cases} \left(\frac{1}{Y_{in}} + (R_s + j0)\right)^{-1} \\ \left(\frac{1}{Y_{in}} + (0 + j \omega L_s)\right)^{-1} \\ \left(\frac{1}{Y_{in}} + \left(0 - j \frac{1}{\omega C_s}\right)\right)^{-1} \end{cases}$$

The program converts this admittance to an impedance for display.

NOTE: An erroneous entry may be corrected by entering the negative of the incorrect value.

### EXAMPLE:

$$f = 4 \text{ MHz}$$



### SOLUTION:

```

FIX2
4.+06 GSB1
50.00 GSB2 |Zin|
50.00 ***
X*Y
0.00 *** ∠Zin
2400.-12 GSB5
15.74 *** |Zin|
X*Y
-71.66 *** ∠Zin
2.56-06 GSB2
GSB5
49.65 *** |Zin|
X*Y
84.28 *** ∠Zin
796.-12 GSB5
497.69 *** |Zin|
X*Y
0.98 *** ∠Zin

```





# Program Listings

7

01 *LBL1	f	50 GSB0	Convert $Y_{in} \rightarrow Z_{in}$
02 2		51 R↓	
03 x		52 RCL6	
04 Pi		53 +	} Add admittances or impedances
05 x	Clear flag	54 X≠Y	
06 CLRG	w	55 RCL7	
07 ST03		56 +	
08 R/S		57 X≠Y	
09 *LBL0	$Z \leftrightarrow Y$	58 RCL0	
10 R↓		59 X≠0?	
11 +P		60 GSB0	
12 1/X		61 R↓	Convert Z→Y
13 X≠Y		62 ST01	
14 CHS		63 X≠Y	
15 X≠Y		64 ST02	
16 +R		65 X≠Y	
17 0		66 0	
18 RTN		67 GSB0	Convert Y→Z
19 *LBL2	R,C,L	68 ST00	Clear flag
20 ST00	Set flag (series)	69 R↓	
21 R/S		70 +P	
22 *LBL3		71 R/S	
23 1/X			*** $ Z_{in}  \angle Z_{in}$
24 RCL0			
25 X=0?			
26 GT08	O,Y (parallel)		
27 0			
28 GT08			
29 *LBL4	O,Z (series)		
30 RCL3			
31 x			
32 1/X	$X_C$ or $B_L$		
33 CHS			
34 0			
35 X≠Y			
36 GT08			
37 *LBL5			
38 RCL3			
39 x	$X_L$ or $B_C$		
40 0			
41 X≠Y			
42 *LBL0			
43 ST07			
44 X≠Y			
45 ST06			
46 RCL2			
47 RCL1			
48 RCL0			
49 X≠0?			
		*** "Printx" may be inserted.	

## REGISTERS

0 flag	1 Re[Y <sub>in</sub> ]	2 Im[Y <sub>in</sub> ]	3 $\omega = 2\pi f$	4	5
6 used	7 used	8	9	10	11
12	13	14	15	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## STANDARD RESISTANCE VALUES\*

For a given tolerance, a "step size" is computed which is used to determine two values, one below and one above the non-standard resistance. These are converted by a subroutine to standard values, and the geometric mean of the latter is calculated. If the given non-standard value is below the mean then the lower standard value is selected; otherwise the larger value is selected.

NOTE: Incorrect results will be obtained for tolerances other than 5%, 10%, or 20%.

REFERENCE: International Telephone and Telegraph Corp.  
Reference Data for Radio Engineers, fourth edition, p. 78.

EXAMPLES: Find the closest standard values for the following:

$$R_1 = 432\Omega$$

$$R_2 = 114\text{ K}\Omega$$

$$R_3 = 3.5\text{ M}\Omega$$

SOLUTION:

ENG4	
5.0000 GSE1	5%
432.0000 GSE2	
430.00+00 ***	$R_1^1$
114.+03 GSE2	
110.00+03 ***	$R_2^1$
3.5+06 GSE2	
3.6000+06 ***	$R_3^1$
10.0000 GSE1	10%
432.0000 GSE2	
470.00+00 ***	$R_1^1$
114.+03 GSE2	
120.00+03 ***	$R_2^1$
3.5+06 GSE2	
3.3000+06 ***	$R_3^1$
20.0000 GSE1	20%
432.0000 GSE2	
470.00+00 ***	$R_1^1$
114.+03 GSE2	
100.00+03 ***	$R_2^1$
3.5+06 GSE2	
3.3000+06 ***	$R_3^1$

\* Adapted from HP-65 Users' Library program #00915A by Jacob Jacobs.



# Program Listings

<pre> 01 *LBL1 02 1 03 2 04 0 05 ÷ 06 10<sup>x</sup> 07 ST02 08 R/S 09 *LBL2 10 LOG 11 ENT↑ 12 INT 13 ST04 14 - 15 1 16 + 17 10<sup>x</sup> 18 ST03 19 1 20 ST-4 21 1 22 0 23 ST05 24 *LBL0 25 RCL3 26 RCL5 27 X&gt;Y? 28 GT09 29 RCL2 30 x 31 ST05 32 GT00 33 *LBL9 34 GSB8 35 ST07 36 RCL5 37 RCL2 38 ÷ 39 GSB8 40 ST06 41 RCL7 42 x 43 IX 44 RCL3 45 X&lt;Y? 46 GSB7 47 RCL7 48 RCL4 49 10<sup>x</sup> </pre>	<pre> 10<sup>tol</sup>/120  This step &gt; Normal R?  This step  Last step  <math>\sqrt{(\text{This step}) * (\text{Last step})}</math> </pre>	<pre> 50 x 51 R/S 52 *LBL8 53 . 54 5 55 + 56 INT 57 ST06 58 2 59 6 60 X&gt;Y? 61 GT06 62 4 63 7 64 RCL6 65 X&gt;Y? 66 GT03 67 1 68 + 69 RTN 70 *LBL3 71 8 72 3 73 RCL6 74 X≠Y? 75 RTN 76 8 77 2 78 RTN 79 *LBL7 80 RCL6 81 ST07 82 RTN 83 *LBL6 84 RCL6 85 RTN 86 R/S </pre>	<pre> 10 EXP R7 *** R  Finds standard R value from multiple of step size  Round up  26&lt;R&lt;47 then add 1  *** "Printx" may be inserted before "R/S". </pre>
--	--	--	---

## REGISTERS

0	1	2 Step size	3 Normal R	4 Exp of R	5 This step
6 Temp	7 Temp	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## EXPONENTIAL GROWTH OR DECAY

Many growth or decay phenomena encountered in science and engineering obey an exponential law of the general form:

$$X_t = X_{ss} - (X_{ss} - X_0) e^{-\frac{t}{\tau}}$$

where:

$X_t$  = Value at any time,  $t$ , (i.e., the instantaneous value)

$X_{ss}$  = Steady state value (i.e., at  $t = \infty$ )

$X_0$  = Initial value (i.e., at  $t = 0$ )

$t$  = Elapsed time (time after  $t = 0$ )

$\tau$  = Exponential time-constant for specific phenomena

This program provides interchangeable solutions for any one of the four variables  $X_t$ ,  $X_{ss}$ ,  $X_0$  or  $t$  provided three variables and  $\tau$  are known.

### EXAMPLE 1:

Given a  $5\mu\text{F}$  capacitor in series with a 1 megohm resistor. 1.5 seconds after the circuit is completed 125 volts are measured across R. To what voltage was the capacitor originally charged?

Note:

$\tau$  = the RC time-constant, and the voltage at  $t = \infty$  is zero

### SOLUTION:

```
5.-06 ENT↑
1.+06  X
      ST04  τ = time-constant
125.00 ST01  V
      0.00 ST02  Xss
      1.50 ST03  time
      GSB0
168.73 *** volts
```

### EXAMPLE 2:

A cobalt 60 source (half-life = 5.26 years) had an activity of 3.54 curies when purchased 8.5 years ago. What is its present activity?

Note:

Activity at  $t = \infty$  will be zero,  
 $\tau$  = half-life/LN2

### SOLUTION:

```
5.26 ENT↑
2.00  LN
      ÷
      ST04  τ
3.54 ST00  X0
      0.00 ST02  Xss
      8.50 ST03  t
      GSB1
1.15 *** curies
```



# Program Listings

13

01 *LBL1	$X_t$		
02 RCL0			
03 RCL2			
04 -			
05 GSB5			
06 ÷			
07 RCL2			
08 +			
09 R/S	***		
10 *LBL2	$X_{ss}$		
11 GSB5			
12 ENT↑			
13 ENT↑			
14 RCL1			
15 x			
16 RCL0			
17 -			
18 XZY			
19 1			
20 -			
21 ÷			
22 R/S	***		
23 *LBL0	$X_0$		
24 GSB5			
25 RCL1			
26 RCL2			
27 -			
28 x			
29 RCL2			
30 +			
31 R/S	***		
32 *LBL3	t		
33 RCL0			
34 RCL2			
35 -			
36 RCL1			
37 RCL2			
38 -			
39 ÷			
40 LN			
41 RCL4			
42 x			
43 R/S	***		
44 *LBL5	$e^{-t/\tau}$		
45 RCL3			
46 RCL4			
47 ÷			
48 e <sup>x</sup>			
49 RTN			
50 R/S			

\*\*\* "Printx" may be inserted  
before "R/S".

REGISTERS					
0 $X_0$	1 $X_t$	2 $X_{ss}$	3 t	4	5
6 $\tau$	7	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29



## EQUATIONS OF MOTION

This program calculates an interchangeable solution among the variables: displacement, acceleration, initial velocity, and time or final velocity for an object that undergoes constant acceleration. The motion must be linear.

EQUATIONS:

$$\text{Final velocity } v = \sqrt{v_0^2 + 2ax}$$

$$\text{Initial velocity } v_0 = \sqrt{v^2 - 2ax}$$

$$\text{Displacement } x = \frac{v^2 - v_0^2}{2a}$$

$$\text{Acceleration } a = \frac{v^2 - v_0^2}{2x}$$

$$\text{Displacement } x = v_0 t + \frac{1}{2} at^2$$

$$\text{Initial velocity } v_0 = \frac{x}{t} - \frac{1}{2} at$$

$$\text{Acceleration } a = \frac{x - v_0 t}{\frac{1}{2} t^2}$$

$$\text{Time } t = \frac{\sqrt{v_0^2 + 2ax} - v_0}{a}$$

REMARKS:

Any consistent set of units may be used.

Displacement, acceleration, and velocity should be considered signed (vector) quantities. For example, if initial

velocity and acceleration are in opposite directions, one should be positive and the other negative.

All equations assume initial displacement,  $x_0$ , equals zero.

EXAMPLE 1:

An automobile accelerates for 4 seconds from a speed of 35 mph and covers a distance of 264 feet. Assuming constant acceleration, what is the acceleration in ft/sec<sup>2</sup>? (7.33 ft/sec<sup>2</sup>) If the acceleration continues to be constant, what distance is covered in the next second? (84.33 ft)

SOLUTION:

```

264.00 ST01  x
35.00 ENT↑
5280.00 x
3600.00 ÷
          ST02  v0
4.00 ST03  t
          GSB4
7.33 *** a

5.00 ST03  t + 1 sec
          GSB1
348.33 *** x at t + 1 sec

264.00 - x at t
84.33 *** x(t+1) - x(t)

```

# EXAMPLE 2:

An airplane's take off velocity is 125 mph. Assume a constant acceleration of 15 ft/sec<sup>2</sup>. How much runway length in feet will be used from start to take-off? (1120.37 ft.) How long will it take for the plane to reach take-off velocity? (12.22 sec)

# SOLUTION:

15

```

0.00 STO2  V0
15.00 STO4
125.00 ENT↑
5280.00 x
3600.00 ÷
STO5  V
GSB7
1120.37 ** x

GSB3
12.22 *** t
    
```

# User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1.	Key in the program		<input type="text"/>	<input type="text"/>	
2.	Store variables		<input type="text"/>	<input type="text"/>	
	displacement	x	STO	1	x
	initial velocity	v <sub>0</sub>	STO	2	v <sub>0</sub>
	time	t	STO	3	t
	acceleration	a	STO	4	a
	final velocity	v	STO	5	v
	(store appropriate unknowns)		<input type="text"/>	<input type="text"/>	
3.	To calculate:		<input type="text"/>	<input type="text"/>	
	A. Displacement(a, v <sub>0</sub> and t or v known)		<input type="text"/>	<input type="text"/>	
	if t is known		GSB	1	x
	if v is known		GSB	7	x
	B. Initial Velocity (a, x, and t or v known)		<input type="text"/>	<input type="text"/>	
	if t is known		GSB	2	v <sub>0</sub>
	if v is known		GSB	6	v <sub>0</sub>
	C. Acceleration (v <sub>0</sub> , x and t or v known)		<input type="text"/>	<input type="text"/>	
	if t is known		GSB	4	a
	if v is known		GSB	8	a
	D. Time (v <sub>0</sub> , x and a known)		GSB	3	t
	E. Final Velocity (v <sub>0</sub> , x and a known)		GSB	5	v
4.	For a new case go to step 2		<input type="text"/>	<input type="text"/>	

# Program Listings

01 *LBL1	x (t known)	51 ST05	
02 RCL2		52 RTN	
03 RCL4		53 *LBL9	
04 2		54 RCL4	
05 ÷		55 RCL1	
06 RCL3		56 x	
07 x		57 x	
08 +		58 +	
09 RCL3		59 JX	
10 x		60 RTN	
11 ST01		61 *LBL6	v <sub>0</sub> (v known)
12 R/S	***	62 RCL5	
13 *LBL2	v <sub>0</sub> (t known)	63 X²	
14 RCL1		64 2	
15 RCL3		65 CHS	
16 ÷		66 GSB9	
17 LSTX		67 ST02	
18 RCL4		68 R/S	***
19 x		69 *LBL7	x ( v known)
20 2		70 4	
21 ÷		71 ST00	
22 -		72 GSB0	
23 ST02		73 ST01	
24 R/S	***	74 R/S	***
25 *LBL4	a (t known)	75 *LBL0	
26 RCL1		76 RCL5	
27 RCL2		77 X²	
28 RCL3		78 RCL2	
29 x		79 X²	
30 -		80 -	
31 RCL3		81 RCL1	
32 X²		82 2	
33 2		83 x	
34 ÷		84 ÷	
35 ÷		85 RTN	
36 ST04		86 *LBL8	a (v known)
37 R/S	***	87 1	
38 *LBL3	t	88 ST00	
39 GSB5		89 GSB0	
40 RCL2		90 ST04	
41 -		91 R/S	***
42 RCL4			
43 ÷			
44 ST03			
45 R/S	***		
46 *LBL5	v		
47 RCL2			
48 X²			
49 2			
50 GSB9			

REGISTERS					
0 Used	1 x	2 v <sub>0</sub>	3 t	4 a	5 v
6	7	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

\*\*\* "Printx" may be inserted  
before "R/S".

## KINETIC ENERGY

This program calculates an interchangeable solution among the variables weight (or mass), velocity, and kinetic energy, for an object moving at constant velocity. The program operates in either English or metric units. For metric units, any consistent set of units may be used; the quantity mass must be used. For English units, the energy must be in foot-pounds, the velocity in feet per second, and the quantity weight in pounds.

K.E. = Kinetic energy

W = Weight (lb)

m = Mass (kg, g)

v = Velocity

g = Acceleration due to gravity =  
32.17398 ft/sec<sup>2</sup>

EQUATIONS:

English

$$K.E. = \frac{1W}{2g} v^2$$

Metric

$$K.E. = \frac{1}{2}mv^2$$

$$1 \text{ ft-lb} = 1.98 \times 10^6 \text{ hp}$$

EXAMPLE 1:

The slider of a slider-crank mechanism is used to punch holes in a slab of metal. It is found that the work required to punch a hole is 775 ft-lb. If the slider weighs 5 lb. 4 oz., how fast must it be moving when it strikes the metal? (97.46 ft/sec) What is the required work in horsepower? (3.91 x 10<sup>-4</sup> hp)

SOLUTION:

```

GSB2
64.35 *** English Units

775.00 ST01
5.00 ENT↑
4.00 ENT↑
16.00 ÷
+
5.25 *** W
ST02

GSB5
97.46 *** v

GSB3
775.00 *** ft-lb
R/S
3.91-04 *** hp

```

EXAMPLE 2:

An object weighing 4.8 kg is moving with constant velocity of 3.5 m/sec. Find its kinetic energy. (29.40 joules)

SOLUTION:

```

GSB1
2.00 *** Metric Units

4.80 ST02
3.50 ST03
GSB3
29.40 *** K.E.

```



# Program Listings

19

01 *LBL1	Metric		
02 2			
03 ST04			
04 R/S			
05 *LBL2	English		
06 6			
07 4			
08 .			
09 3			
10 4			
11 7			
12 9			
13 6			
14 ST04			
15 R/S			
16 *LBL3	K.E. Calc.		
17 RCL2			
18 RCL3			
19 ENT↑			
20 x			
21 x			
22 RCL4			
23 ÷			
24 ST01	***		
25 R/S			
26 RCL1			
27 1			
28 9			
29 8			
30 EEX			
31 4			
32 ÷	***		
33 R/S			
34 *LBL4	W(m) Calc.		
35 RCL1			
36 RCL4			
37 x			
38 RCL3			
39 ENT↑			
40 x			
41 ÷			
42 ST02	***		
43 R/S			
44 *LBL5	v Calc.		
45 RCL1			
46 RCL4			
47 x			
48 RCL2			
49 ÷			
50 JX			
51 ST03	***		
52 R/S			

\*\*\*"Printx" may be inserted before "R/S".

REGISTERS					
0	1 K.E.	2 W(m)	3 v	4 2(met) 64.3(Eng)	
6	7	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## RPM/TORQUE/POWER

This program provides an interchangeable solution for RPM, torque, and power in both Systeme International (metric) and English units.

	SI	English
RPM	RPM	RPM
Torque	nt-m	ft-lb
Power	watts	hp

EQUATIONS:

$$\text{RPM} \times \text{Torque} = \text{Power}$$

$$1 \text{ hp} = 745.7 \text{ watts}$$

$$1 \text{ ft-lb} = 1.356 \text{ joules}$$

$$1 \text{ RPM} = \pi/30 \text{ radians/sec}$$

$$1 \text{ hp} = 550 \frac{\text{ft-lb}}{\text{sec}}$$

EXAMPLE 1:

Calculate the torque from an engine developing 11 hp at 6500 RPM. Find the SI equivalent.

EXAMPLE 2:

A generator is turning at 1600 RPM with a torque of 20 nt-m. If it is 90% efficient, what is the power input in both systems?

SOLUTIONS:

(1)

```

          GSB4
6500.00 ENT↑
          0.00 ENT↑
          11.00 GSB5
          8.89 *** Torque, ft-lb
              R/S
          12.05 *** Torque, nt-m

```

(2)

```

          GSB3
1600.00 ENT↑
          20.00 ENT↑
          0.90 ÷
          0.00 GSB5
3723.37 *** Power, watts
              R/S
          4.99 *** Power, hp

```





# Program Listings

01 *LBL3	Set up for metric units	48 RCL3	** RPM
02 3		49 ÷	
03 0		50 RCL7	
04 Pi		51 x	
05 ÷		52 R/S	
06 ST07		53 *LBL1	
07 7		54 RCL4	
08 4		55 RCL2	
09 5		56 ÷	
10 .		57 RCL7	
11 7		58 x	
12 ST05		59 R/S	
13 1		60 RCL6	
14 .		61 ÷	
15 3		62 R/S	
16 5		63 *LBL0	
17 6		64 RCL2	
18 ST06		65 RCL3	
19 RTN	Set up for English units	66 x	*** Torque
20 *LBL4		67 RCL7	
21 GSB3		68 ÷	
22 1/X		69 R/S	
23 ST06		70 RCL5	
24 X*Y		71 ÷	
25 1/X		72 R/S	
26 ST05			
27 ÷			
28 x			
29 ST07			
30 RTN			
31 *LBL5			
32 4			
33 ST00			
34 R↓			
35 *LBL8	Store variables		** "Printx" may be inserted before "R/S". *** "Printx" may replace "R/S".
36 ST01			
37 R↓			
38 DSZ			
39 GT08			
40 *LBL9			
41 X=0?			
42 GT01			
43 ISZ			
44 R↓			
45 GT09			
46 *LBL2			
47 RCL4			
	Determine quantity to calculate		

## REGISTERS

0 i	1 Used	2 RPM	3 Torque	4 Power	5 Used
6 Used	7 Used	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## BLACK BODY THERMAL RADIATION

Bodies with finite temperatures emit thermal radiation. The higher the absolute temperature, the more thermal radiation emitted. Bodies which emit the maximum possible amount of energy at every wavelength for a specified temperature are said to be black bodies. While black bodies do not actually exist in nature, many surfaces may be assumed to be black for engineering considerations.

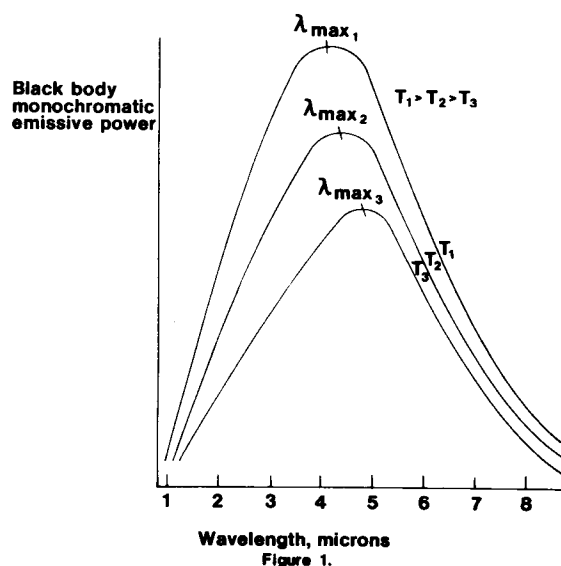


Figure 1 is a representation of black body thermal emission as a function of wavelength. Note that as temperature increases the area under the curves (total emissive power  $E_b(0-\infty)$ ) increases. Also note that the wavelength of maximum emissive power  $\lambda_{\max}$  shifts to the left as temperature increases.

This program can be used to calculate the wavelength of maximum emissive power for a given temperature, the temperature corresponding to a particular wavelength of maximum emissive power, the total emissive power for all wavelengths and the emissive power at

a particular wavelength. It can also be used to calculate the emissive power from zero to an arbitrary wavelength, the emissive power between two wavelengths or the total emissive power.

### EQUATIONS:

$$\lambda_{\max} T_{\lambda_{\max}} = c_3$$

$$E_b(0-\infty) = \sigma T^4$$

$$E_{b\lambda} = \frac{2\pi c_1}{\lambda^5 (e^{c_2/\lambda T} - 1)}$$

$$E_b(0-\lambda) = \int_0^\lambda E_{b\lambda} d\lambda$$

$$= 2\pi c_1 \sum_{k=1}^{\infty} -T/kc_2 e^{-\frac{kc_2}{T\lambda}} \left[ \left( \frac{1}{\lambda} \right)^3 + \frac{3T}{\lambda^2 kc_2} + \frac{6}{\lambda} \left( \frac{T}{kc_2} \right)^2 + 6 \left( \frac{T}{kc_2} \right)^3 \right]$$

$$E_b(\lambda_1-\lambda_2) = E_b(0-\lambda_2) - E_b(0-\lambda_1)$$

where

$\lambda_{\max}$  is the wavelength of maximum emissivity in microns;

$T$  is the absolute temperature in  $^{\circ}\text{R}$  or  $\text{K}$ ;

$E_{b(0-\infty)}$  is the total emissive power  
in Btu/hr-ft<sup>2</sup> or Watts/cm<sup>2</sup>;

$E_{b\lambda}$  is the emissive power at  $\lambda$  in  
Btu/hr-ft<sup>2</sup>- $\mu\text{m}$  or Watts/cm<sup>2</sup>- $\mu\text{m}$ ;

$E_{b(0-\lambda)}$  is the emissive power for  
wavelengths less than  $\lambda$  in  
Btu/hr-ft<sup>2</sup> or Watts/cm<sup>2</sup>;

$E_{b(\lambda_1-\lambda_2)}$  is the emissive power for  
wavelengths between  $\lambda_1$  and  $\lambda_2$   
in Btu/hr-ft<sup>2</sup> or Watts/cm<sup>2</sup>.

$$c_1 = 1.8887982 \times 10^7 \text{ Btu-}\mu\text{m}^4/\text{hr-ft}^2 \\ = 5.9544 \times 10^3 \text{ W}\mu\text{m}^4/\text{cm}^2$$

$$c_2 = 2.58984 \times 10^4 \mu\text{m-}^\circ\text{R} = \\ 1.4388 \times 10^4 \mu\text{m-K}$$

$$c_3 = 5.216 \times 10^3 \mu\text{m-}^\circ\text{R} = \\ 2.8978 \times 10^3 \mu\text{m-K}$$

$$\sigma = 1.71312 \times 10^{-9} \text{ Btu/hr-ft}^2\text{-}^\circ\text{R}^4 = \\ 5.6693 \times 10^{-12} \text{ W/cm}^2\text{-K}^4$$

$$\sigma_{\text{exp}} = 1.731 \times 10^{-9} \text{ Btu/hr-ft}^2\text{-}^\circ\text{R}^4 \\ = 5.729 \times 10^{-12} \text{ W/cm}^2\text{-K}^4$$

#### REMARKS:

A minute or more may be required to  
obtain  $E_{b(0-\lambda)}$  or  $E_{b(\lambda_1-\lambda_2)}$  since the  
integration is numerical.

Sources differ on values for constants.  
This could yield small discrepancies  
between published tables and outputs.

#### REFERENCE:

Robert Siegel and John R. Howell,  
Thermal Radiation Heat Transfer, Vol. 1,  
National Aeronautics and Space Admin-  
istration, 1968.

#### EXAMPLE 1:

What percentage of the radiant output  
of a lamp is in the visible range (0.4  
to 0.7 microns) if the filament of the  
lamp is assumed to be a black body at  
2400 K?

#### EXAMPLE 2:

If the human eye was designed to work  
most efficiently in sunlight and the  
visible spectrum runs from about 0.4 to  
0.7 microns, what is the sun's tempera-  
ture in degrees Rankine? Assume that  
the sun is a black body. Using the  
temperature calculated, find the frac-  
tion of the sun's total emissive power  
which falls in the visible range. Find  
the percentage of the sun's radiation  
which has a wavelength less than 0.4  
microns.

#### SOLUTIONS:

1.

5954.40 ST01	} S.I. constants
14388.00 ST02	
2897.80 ST03	
5.6693-12 ST04	
2400.00 ST05	
0.40 ST06	
0.70 ST07	
GSB4	
4.97 ***	
GSB2	$E_b (0 \text{ to } \infty)$
=	
100.00 %	
2.64 *** (%)	

2.

18887982.00	ST01	} English constants
25898.40	ST02	
5216.00	ST03	
1.71312-09	ST04	

0.40 ENT↑

0.70 +

2.00 ÷

0.55 \*\*\* mean value

RCL3

÷

1/X

9483.64 \*\*\* T, (°R)

ST05

0.40 ST06

0.70 ST07

GSB4

4670556.56 \*\*\* E<sub>b</sub>(.4 to .7)

GSB2

13857578.83 \*\*\* E<sub>b</sub>(0 to ∞)

÷

100.00 ×

33.70 \*\*\* (%)

0.40 ST06

GSB1

1168606.94 \*\*\* E<sub>b</sub> (0 to .4)

GSB2

÷

100.00 ×

8.43 \*\*\* (%)

# User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS		OUTPUT DATA/UNITS
1	Key in the program		<input type="text"/>	<input type="text"/>	
2	Store constants:		<input type="text"/>	<input type="text"/>	
2a	English units -	18887982	STO	1	
	(Btu, $\mu\text{m}$ , ft, $^{\circ}\text{R}$ )	25898.4	STO	2	
		5216	STO	3	
	or .171312 x 10 <sup>-8</sup>		STO	4	
2b	SI units -	5954.4	STO	1	
	(W, $\mu\text{m}$ , cm, $^{\circ}\text{K}$ )	14388	STO	2	
		2897.8	STO	3	
	5.6693 x 10 <sup>-12</sup>		STO	4	
3	For experimental Stefan-Boltzmann constant	1.0105	STO	x	
	instead of theoretical constant		4		
4	To calculate $\lambda_{\text{max}} = f(T)$		RCL	3	
		T ( $^{\circ}\text{R}$ or k)	$\div$		$\lambda_{\text{max}}(\mu\text{m})$
5	To calculate T = f( $\lambda$ ) for which $\lambda$ is		RCL	3	
	maximum	$\lambda(\mu\text{m})$	$\div$		T ( $^{\circ}\text{R}$ or k)
6	To calculate total emissive power	T*	STO	5	
			GSB	2	$E_b(0 \text{ to } \infty)$
7	To calculate emissive power at $\lambda$	T*	STO	5	
		$\lambda$	STO	6	
			GSB	3	$E_b(\lambda)$
8	To calculate emissive power from 0 to $\lambda_1$	T*	STO	5	
		$\lambda_1$	STO	6	
			GSB	1	$E_{b(0 \text{ to } \lambda_1)}$
9	To calculate emissive power from $\lambda_1$ to $\lambda_2$	T*	STO	5	
		$\lambda_1$	STO	6	
	*any value of T stored previously is still	$\lambda_2$	STO	7	
	stored and need not be input again		GSB	4	$E_{b(\lambda_1 \text{ to } \lambda_2)}$

# Program Listings

01 *LBL1		50 X<Y?	$\Delta \geq .001\%$		
02 GSB9		51 GT00	yes, increment k		
03 R/S	***E <sub>b(0 to <math>\lambda_1</math>)</sub>	52 RCL9			
04 *LBL9		53 2			
05 0		54 x			
06 ST09		55 Pi			
07 ST08		56 x			
08 *LBL0		57 RCL1			
09 RCL2		58 x			
10 RCL5		59 RTN	E <sub>b(0 to <math>\lambda</math>)</sub>		
11 ÷		60 *LBL2			
12 ST-8	-k c <sub>2</sub> /T	61 RCL5			
13 3		62 4			
14 RCL8		63 Y*			
15 ÷		64 RCL4			
16 RCL6		65 x			
17 X <sup>2</sup>		66 R/S	***E <sub>b(0 to <math>\infty</math>)</sub>		
18 ÷		67 *LBL3			
19 LSTX	$\lambda^2$	68 RCL1			
20 RCL6		69 2			
21 x		70 x			
22 1/X		71 Pi			
23 -		72 x			
24 6		73 RCL6			
25 RCL6		74 5			
26 ÷		75 Y*			
27 RCL8		76 ÷			
28 X <sup>2</sup>		77 RCL2			
29 ÷		78 RCL6			
30 -		79 ÷			
31 6		80 RCL5			
32 RCL8		81 ÷			
33 3		82 e <sup>x</sup>			
34 Y*		83 1			
35 ÷		84 -			
36 +		85 ÷			
37 RCL8		86 R/S	***E <sub>b<math>\lambda</math></sub>		
38 RCL6		87 *LBL4			
39 ÷		88 GSB9			
40 e <sup>x</sup>		89 ST.0	E <sub>b(0 to <math>\lambda_1</math>)</sub>		
41 x		90 RCL7			
42 RCL8		91 ST06	$\lambda_2$		
43 ÷		92 GSB9			
44 ST+9	$\Delta$	93 RC.0			
45 RCL9		94 -			
46 ÷		95 R/S	***E <sub>b(<math>\lambda_1</math> to <math>\lambda_2</math>)</sub>		
47 EEX					
48 CHS					
49 5					
***"Printx" may be inserted before "R/S"					
REGISTERS					
0	1 c <sub>1</sub>	2 c <sub>2</sub>	3 c <sub>3</sub>	4 $\sigma$	5 T
6 $\lambda$	7 $\lambda_2$	8 -Kc <sub>2</sub> /T	9 sum	10 used	11
12	13	14	15	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## CONSERVATION OF ENERGY

This program converts kinetic energy, potential energy, and pressure-volume work to energy. Energy is stored as a running total which may at any time be converted to an equivalent velocity, height, pressure, or energy per unit mass. The program is useful in fluid flow problems where velocity, elevation and pressure change along the path of flow.

### EQUATIONS:

$$\frac{v_1^2}{2} + gz_1 + \frac{P_1}{\rho} + \frac{E_1}{\dot{m}} =$$

$$\frac{v_2^2}{2} + gz_2 + \frac{P_2}{\rho} + \frac{E_2}{\dot{m}}$$

where:

- v is the fluid velocity;
- z is the height above a reference datum;
- P is the pressure;
- E is an energy term which could represent inputs of work or friction losses (negative value);
- g is the acceleration of gravity;
- $\rho$  is the fluid density;
- $\dot{m}$  is the mass flow rate (assumed to be unity);
- subscripts 1 and 2 refer to upstream and downstream values respectively.

### NOTES:

Downstream values should be input as negatives. However, when an output is called for, the calculator displays the relative value with no regard to upstream or downstream location.

An error will result when the total energy sum stored in register 8 is negative and an attempt is made to calculate velocity.

### EXAMPLE 1:

A water tower is 100 feet high. What is the zero flow rate pressure at the base? The density of water is 62.4 lb/ft<sup>3</sup>.

If water is flowing out of the tower at a velocity of 10 ft/sec, what is the static pressure?

What is the maximum frictionless flow velocity which could be achieved with the 100 foot tower?

If 10000 pounds of water are pumped to the top of the tower every hour, at a velocity of 20 ft/sec, with a frictional pressure drop of 2 psi, how much power is needed at the pump?

### EXAMPLE 2:

An incompressible fluid ( $\rho = 735 \text{ kg/m}^3$ ) flows through the converging passage of Figure 1. At point 1 the velocity is 3 m/s and at point 2 the velocity is 15 m/s. The elevation difference between points 1 and 2 is 3.7 meters. Assuming frictionless flow, what is the static pressure difference between points 1 and 2?

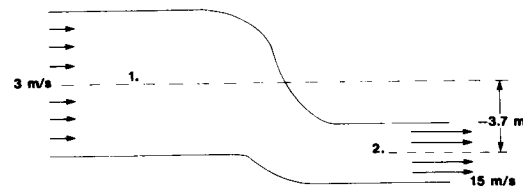


Figure 1.

EXAMPLE 3:

A reservoir's level is 25 meters above the discharge pond. Assuming 85% power generation efficiency, how much power can be generated with a flow rate of  $20 \text{ m}^3/\text{s}$ ?

$$\rho = 1000 \text{ kg/m}^3$$

SOLUTIONS:

(1) 25033.407 ST05  
 32.17 ST06  
 4632.48 ST07  
 62.40 GSB1  
 100.00 GSB3  
 GSB8  
 43.33 \*\*\* (psig)  
 -10.00 GSB2  
 GSB8  
 42.66 \*\*\* (psig)  
 62.40 GSB1  
 100.00 GSB3  
 GSB6  
 80.21 \*\*\* (ft/sec)  
 62.40 GSB1  
 20.00 GSB2  
 2.00 GSB4  
 100.00 GSB3  
 GSB9  
 0.14 \*\*\* (BTU/lb)  
 10000.00 x  
 1424.29 \*\*\* (BTU/hr)

(2) 1.00 ST05  
 ST07  
 9.80665 ST06  
 735.00 GSB1  
 3.00 GSB2  
 3.70 GSB3  
 -15.00 GSB2  
 GSB8  
 -52710.82 \*\*\* (Nt/m<sup>2</sup>)

(3) 1000.00 GSB1  
 25.00 GSB3  
 GSB9  
 245.17 \*\*\* (joule/kg)  
 0.85 x  
 208.39 \*\*\* (joule/kg)  
 20.00 ENT†  
 1000.00 x (kg/s)  
 x  
 4167826.25 \*\*\* (watts)





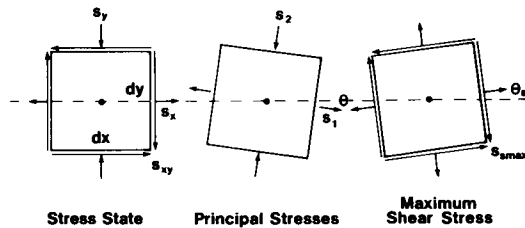
# Program Listings

31

01 *LBL1					
02 ST04	$\rho$				
03 0					
04 ST08	Clear $\Sigma E$				
05 R/S					
06 *LBL2					
07 ENT↑					
08 ABS					
09 x					
10 2					
11 ÷	$\pm v^2/2$				
12 GT05					
13 *LBL3					
14 RCL6					
15 x					
16 GT05	gz				
17 *LBL4					
18 RCL7					
19 x					
20 RCL4					
21 ÷	$\rho/\rho$				
22 *LBL5	E				
23 ST+8					
24 R/S					
25 *LBL6					
26 RCL8					
27 2					
28 x					
29 JX					
30 R/S	*** v				
31 *LBL7					
32 RCL8					
33 RCL6					
34 ÷					
35 R/S	*** z				
36 *LBL8					
37 RCL8					
38 RCL7					
39 ÷					
40 RCL4					
41 x					
42 R/S	*** p				
43 *LBL9					
44 RCL8					
45 RCL5					
46 ÷					
47 R/S	*** E				
*** "Printx" may be inserted before "R/S".					
REGISTERS					
0	1	2	3	4 $\rho$	5 Used
6 g	7 Used	8 $\Sigma E$	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

## MOHR CIRCLE FOR STRESS

Given the state of stress on an element, the principal stresses and their orientation can be found. The maximum shear stress and its orientation can also be found.



### EQUATIONS:

$$s_{smax} = \sqrt{\left(\frac{s_x - s_y}{2}\right)^2 + s_{xy}^2}$$

$$s_1 = \frac{s_x + s_y}{2} + s_{smax}$$

$$s_2 = \frac{s_x + s_y}{2} - s_{smax}$$

$$\theta = \frac{1}{2} \tan^{-1} \left( \frac{2s_{xy}}{s_x - s_y} \right)$$

$$\theta_s = \frac{1}{2} \tan^{-1} - \left( \frac{s_x - s_y}{2s_{xy}} \right)$$

where:

$s_{smax}$  is the maximum shear stress;

$s_1$  and  $s_2$  are the principal normal stresses;

$\theta$  is the angle of rotation from the principal axis to the original axis;

$\theta_s$  is the angle of rotation from the axis of maximum shear stress to the original axis;

$s_x$  is the stress in the x direction;

$s_y$  is the stress in the y direction;

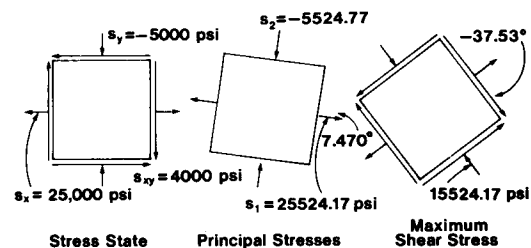
$s_{xy}$  is the shear stress on the element.

### REFERENCE:

Spotts, M.F., Design of Machine Elements, Prentice-Hall, 1971.

### EXAMPLE:

If  $s_x = 25000$  psi,  $s_y = -5000$  psi, and  $s_{xy} = 4000$  psi, compute the principal stresses and the maximum shear stress.



SOLUTION:

```
25000.00 ENT↑  
-5000.00 ENT↑  
4000.00 GSB1  
25524.17 ***  
          R/S  s1 (psi)  
-5524.17 ***  s2 (psi)  
          R/S  
    7.47 ***  θ (degrees)  
          R/S  
   -37.53 ***  θs (degrees)  
          R/S  
15524.17 ***  ssmax (psi)
```



# Program Listings

35

01 *LBL1					
02 ENT↑					
03 R↓	$s_{xy}$	$s_y$	$s_x$	$s_{xy}$	
04 ST03					
05 R↓					
06 X↔Y	$s_x$				
07 ST01					
08 X↔Y	$s_y$				
09 ST+1					
10 -	$s_x - s_y$				
11 2					
12 ST=1					
13 ÷	$(s_x - s_y)/2$				
14 ST04					
15 +P	$s_{smax}$				
16 ST02					
17 RCL1					
18 +	** S1				
19 R/S	$2 \cdot \theta$				
20 X↔Y					
21 RCL1					
22 RCL2					
23 -	** S2				
24 R/S					
25 X↔Y					
26 2					
27 ÷	** $\theta$				
28 R/S					
29 RCL4					
30 RCL3					
31 ÷					
32 CHS					
33 TAN <sup>-1</sup>					
34 2					
35 ÷	** $\theta_s$			** "Printx" may replace "R/S".	
36 R/S					
37 RCL2					
38 R/S	*** $s_{smax}$			*** "Printx" may be inserted before "R/\$".	
REGISTERS					
0	1 $(s_x + s_y)/2$	2 $s_{smax}$	3 $s_{xy}$	4 $(s_x - s_y)/2$	5
6	7	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

# POLYNOMIAL EVALUATION--REAL OR COMPLEX

This program evaluates polynomials of the form:

$$f(x_0) = a_0 + a_1x + \dots + a_nx^n$$

where the coefficients

$a_k, k=0, \dots, n (n \leq 28)$  and  $x_0$  are real or the coefficients and  $x_0$  are complex of the form

$$a_k = \text{Re}(a_k) + i \text{Im}(a_k)$$

$$z_0 = \text{Re}(z_0) + i \text{Im}(z_0)$$

$$k = 0, 1, \dots, n$$

Example 1:

$$f(x) = 11 - 7x - 3x^2 + 5x^4 + x^5$$

$$\text{for } x_0 = 2.5$$

$$\text{for } x_0 = -5$$

Solution:

```

      CLR
11.00 GSB1
-7.00 R/S
-3.00 R/S
 0.00 R/S
 5.00 R/S
 1.00 R/S
 2.50 GSB2
267.72 *** f (2.5)
 6.00 STO0
-5.00 GSB2
-29.00 *** f (-5)

```

Example 2:

$$f(x) = (5-7i) - 10x + (-2+i)x^2 + 18x^3 + (3+4i)x^4$$

$$\text{for } x_0 = 2 + i$$

Solution:

```

1.00 ENT↑
2.00 GSB3
4.00 ENT↑
3.00 GSB4
0.00 ENT↑
10.00 GSB4
 1.00 ENT↑
-2.00 GSB4
 0.00 ENT↑
-10.00 GSB4
-7.00 ENT↑
 5.00 GSB5
-106.00 *** Re f(x_0)
      R/S
220.00 *** Im f(x_0)

```





01 *LBL1		50 *LBL9	Add real parts and
02 ISZ		51 X $\div$ Y	imaginary parts
03 STOI		52 R $\downarrow$	
04 R/S		53 +	
05 GTOI		54 R $\downarrow$	
06 *LBL2		55 +	
07 ENT $\uparrow$		56 X $\div$ Y	
08 ENT $\uparrow$		57 R $\downarrow$	
09 ENT $\uparrow$		58 X $\div$ Y	
10 RCLi		59 RTN	
11 X	Multiply by $x_0$	60 R/S	
12 DSZ			
13 *LBL0			
14 RCLi			
15 +	Multiply by $x_0$		
16 X			
17 DSZ			
18 GTO0			
19 X $\div$ Y	Divide by $x_0$		
20 =	*** $f(x_0)$		
21 R/S	Routines for		
22 *LBL3	complex polynomials		
23 $\rightarrow$ P	r		
24 STOI	$\theta$		
25 X $\div$ Y	Prepare for LBL 9		
26 STOI			
27 0			
28 ENT $\uparrow$			
29 ENT $\uparrow$			
30 ENT $\uparrow$			
31 RTN			
32 *LBL4			
33 GSB9			
34 GTO0			
35 *LBL5			
36 GSB9			
37 R/S	*** Re $f(x_0)$		
38 X $\div$ Y			
39 R/S	*** Im $f(x_0)$		
40 *LBL8	Multiply in polar		
41 $\rightarrow$ P	form		
42 RCL1			
43 X			
44 X $\div$ Y			
45 RCL2			
46 +			
47 X $\div$ Y			
48 $\rightarrow$ R			
49 RTN			

REGISTERS					
0 i	1 r or $a_0$	2 $\theta$ or $a_1$	3 $a_2$	4 . . . $a_n$	5
6	7	8	9	.0	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29 $a_{28}$

\*\*\* "Printx" may be inserted or used to replace "R/S".

## SINE, COSINE, AND EXPONENTIAL INTEGRALS

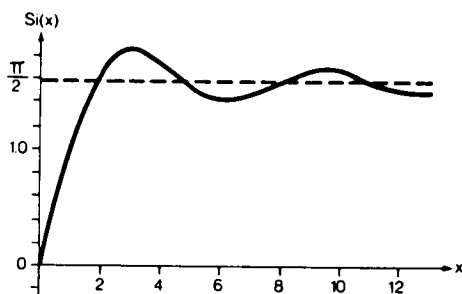
Sine integral:

$$Si(x) = \int_0^x \frac{\sin t}{t} dt =$$

$$\sum_{n=0}^{\infty} \frac{(-1)^n x^{2n+1}}{(2n+1)(2n+1)!}$$

where  $x$  is real.

This routine computes successive partial sums of the series, stops when two consecutive partial sums are equal, and displays the last partial sum as the answer.



Notes: When  $x$  is too large, computing a new term of the series might cause an overflow. In that case, display shows all 9's and the program stops.

$$Si(-x) = -Si(x)$$

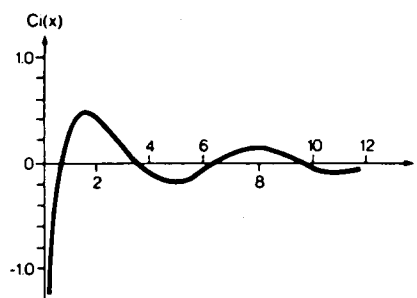
Cosine integral:

$$Ci(x) = \gamma + \ln x + \int_0^x \frac{\cos t - 1}{t} dt =$$

$$\gamma + \ln x + \sum_{n=1}^{\infty} \frac{(-1)^n x^{2n}}{2n(2n)!}$$

where  $x > 0$ , and  $\gamma = 0.577215665$  is the Euler's constant.

This program computes successive partial sums of the series. When two consecutive partial sums are equal, the value is used as the sum of the series.



Notes: When  $x$  is too large, computing a new term of the series might cause an overflow. In that case, display shows all 9's and the program stops.

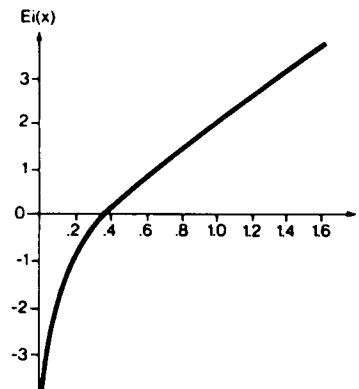
$$Ci(-x) = Ci(x) - i\pi \text{ for } x > 0.$$

Exponential integral:

$$Ei(x) = \int_{-\infty}^x \frac{e^t}{t} dt = \gamma + \ln x + \sum_{n=1}^{\infty} \frac{x^n}{nn!}$$

where  $x > 0$  and  $\gamma = 0.577215665$  is Euler's constant.

This program computes successive partial sums of the series. When two consecutive partial sums are equal, the value is used as the sum of the series.



Note: When  $x$  is too large, computing a new term of the series might cause an overflow. In that case, display shows all 9's and the program stops.

References: Handbook of Mathematical Functions, Abramowitz and Stegun, National Bureau of Standards, 1968.

Examples:

1. Si (.69)
2. Si (.98)
3. Ci (1.38)
4. Ci (5)
5. Ei (1.59)
6. Ei (.61)

Solutions:

```
0.577215665 ST.0
0.69 GSB1
0.67 ***
0.98 GSB1
0.93 ***
1.38 GSB2
0.46 ***
5.00 GSB2
-0.19 ***
1.59 GSB3
3.57 ***
0.61 GSB3
0.80 ***
```

## User Instructions

STEP	INSTRUCTIONS	INPUT DATA/UNITS	KEYS	OUTPUT DATA/UNITS
1.	Key in the program		<input type="text"/> <input type="text"/>	
			<input type="text"/> <input type="text"/>	
2.	Store $\alpha$	.577215665	STO <input type="text"/>	
			0 <input type="text"/>	$\alpha$
			<input type="text"/> <input type="text"/>	
3.	For Sine Integral	x	GSB 1	Si(x)
	For Cosine Integral	x	GSB 2	Ci(x)
	For Exponential Integral	x	GSB 3	Ei(x)
			<input type="text"/> <input type="text"/>	

01 *LBL1	<div>Sine Integral routine</div> <div>*** Si(x)/Ci(x) Cosine Integral routine</div> <div>Exponential In- tegral routine</div>	50 RC.0	<div>*** Ei(x)</div>
02 ST03		51 +	
03 X <sup>2</sup>		52 *LBL9	
04 CHS		53 RCL1	
05 ST01		54 RCL2	
06 1		55 1	
07 ST02		56 +	
08 RCL3		57 ST02	
09 *LBL0		58 ÷	
10 RCL1		59 RCL3	
11 RCL2		60 x	
12 1		61 ST03	
13 +		62 RCL2	
14 ÷		63 ÷	
15 LSTX		64 +	
16 1		65 X*Y?	
17 +		66 GT09	
18 ST02		67 R/S	
19 ÷			
20 RCL3			
21 x			
22 ST07			
23 RCL2			
24 ÷			
25 +			
26 X*Y?			
27 GT00			
28 R/S			
29 *LBL2			
30 X <sup>2</sup>			
31 CHS			
32 ST01			
33 1			
34 ST03			
35 0			
36 ST02			
37 LSTX			
38 LN			
39 RC.0			
40 +			
41 GT00			
42 *LBL3			
43 ST01			
44 1			
45 ST03			
46 0			
47 ST02			
48 RCL1			
49 LN			

REGISTERS					
0	1 used	2 used	3 used	4	5
6	7	8	9	.0 used	.1
.2	.3	.4	.5	16	17
18	19	20	21	22	23
24	25	26	27	28	29

\*\*\* "Print X" may be used to replace "R/S".

In the Hewlett-Packard tradition of supporting HP programmable calculators with quality software, the following titles have been carefully selected to offer useful solutions to many of the most often encountered problems in your field of interest. These ready-made programs are provided with convenient instructions that will allow flexibility of use and efficient operation. We hope that these Solutions books will save your valuable time. They provide you with a tool that will multiply the power of your HP-19C or HP-29C many times over in the months or years ahead.

**Mathematics Solutions**

**Statistics Solutions**

**Financial Solutions**

**Electrical Engineering Solutions**

**Surveying Solutions**

**Games**

**Navigational Solutions**

**Civil Engineering Solutions**

**Mechanical Engineering Solutions**

**Student Engineering Solutions**



Scan Copyright ©  
The Museum of HP Calculators  
[www.hpmuseum.org](http://www.hpmuseum.org)

Original content used with permission.

Thank you for supporting the Museum of HP  
Calculators by purchasing this Scan!

Please to not make copies of this scan or  
make it available on file sharing services.